The challenges and the potential of the knowldege-based economy in a globalised world

2. The challenges and the potential of the knowledge-based economy in a globalised world

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INTRODUCTION

The Portuguese presidency of the EU came at a crucial time. The first six months of 2000, the last year of the second millennium, represented to some extent an ideal moment to take stock of where Europe had been heading since the economic integration process had been set in motion after the massive devastations of the Second World War, and, in particular, how Europe had adjusted to the major, world-wide structural transformations. The last decade of the twentieth century has been a period of major structural transformations world wide, but also quite explicitly in Europe. At the beginning of the decade, one witnessed the albeit sudden collapse of the former communist East European countries and their rapid opening up to market-led economic incentives, with as the most extreme case the economic and political integration of East Germany with West Germany and the European Union (EU). A year later, the fifteen EU member countries formally entered the European Single Market: a process of economic integration still incomplete today in many, non-manufacturing utilities and service sectors but having nevertheless brought about a gradual opening-up of many, traditionally closed, domestic markets. Less precise in timing but again, once initiated, progressing at an accelerating rate, financial markets underwent during the nineties a dramatic, world-wide deregulation. Independent domestic monetary policy became something of the past. More recently, the European telecommunications sector became deregulated and liberalised. The resulting growth and variety in telecom services being offered has been so strong that at least up to 2000, and against most forecast and predictions, no overall job losses in the telecom sector took place, rather the contrary. And, finally, there was of course the macroeconomic convergence process leading to monetary union with the formal introduction of the euro on 1 January 1999 in eleven EU member countries.

Alongside these major, policy-led structural transformations, sometimes causing them, sometimes enabling them, there was of course the rapid rate of technological change in information and communication technologies. Three specific features of these technologies have been instrumental in bringing about further structural transformations in the economic, social and organisational framework of our society, opening up an increasing number of sectors to international trade and restructuring. First, the dramatic reduction in the costs of information and communication processing; second, the technologically-driven 'digital convergence' between communication and computer technology; and, third, the rapid growth in international electronic networking.

Many of these structural transformation processes, such as those with respect to financial markets or even the telecom liberalisation process have been global in nature. They have, however, involved much more some regions or areas than others. While Europe appears to have been at the centre of most of the structural transformations listed above, it seems, as yet, to have benefited least from the growth opportunities behind these structural transformation processes. In saying this, care must of course be taken in acknowledging the variety of experiences in individual member countries.

This is why we start our analysis with a very short, bird's eye overview of Europe's aggregate growth performance over the last decade(s): the EU as a whole in comparison with the US and Japan, and the individual growth performance of individual member countries. In a second section, we then address, albeit briefly, some of the main concepts used in the emerging so-called knowledge-based economy. Obviously the impact of new information and communication technologies does not limit itself to the manufacturing and distribution of goods and services. Similar, fundamental transformations are likely to occur in the production, distribution and organisation of research activities and knowledge generation more generally. In a third section we briefly discuss Europe's performance in knowledge investment. The evidence presented suggests that a significant gap has emerged over the 1990s between the US and Europe in knowledge investment, and information and communication technology (ICT)-related knowledge investment in particular. From this perspective the US seems to have been much more successful than Europe in making its transition in the 1990s towards a knowledge-based economy. In the fourth section, we draw some policy insights from this US experience. In particular, we highlight a number of features, which seem to lie behind the US growth story. The focus of our analysis is on those elements which might be of particular relevance to Europe and might lend themselves to concerted policy action at the European level. Again, it must be emphasised that the variety of individual European country experiences renders any such aggregate comparison difficult. Sometimes comparison with the US might even not be particularly relevant and more could be learnt from the 'best practice' experience of other EU member countries. However, as an aggregate large 'single' market, comparisons of the EU with the US are particularly revealing in highlighting the many remaining barriers and impediments to benefiting in the areas of knowledge investment and growth from Europe's large market.

It is from this perspective, that, as we stress in the conclusions, a number of policy recommendations can be formulated. Far from being complete and all encompassing, these recommendations illustrate that in a number of areas there is today a need for a new, post-EMU, knowledge-investment-based, European policy agenda.[1]

2. EUROPE'S RECENT GROWTH EXPERIENCE IN HISTORICAL PERSPECTIVE

We start the analysis with a brief overview of some of the main aggregate economic trends over the post-war period and the 1990s in particular. We focus on the European Union as a whole in comparison with the United States and Japan.

Figure 2.1 shows the growth rate in real gross domestic product (GDP) in the US, the EU and Japan. To facilitate comparisons, GDP levels have been set for 1991 at 1. From Figure 2.1 it emerges that since 1991, US real GDP has grown by some 38 per cent, an average of more than 3 per cent a year, the EU by some 19 per cent, an average of some 2 per cent a year and Japan by some 9 per cent, an average of less than 1 per cent a year. At the same time, as illustrated in Figure 2.2, employment grew also much more significantly in the US than in Europe or Japan. In Europe employment growth only turned positive since 1995, when output growth accelerated.

Behind this European average over the 1990s of 'jobless' growth, very different growth and employment trends can be observed for individual member countries. At one extreme, Ireland, the Netherlands and Denmark resembled much more the US pattern of rapid output and employment growth, whereas at the other extreme Germany and Italy witnessed sluggish output growth with declining employment. Rather than talking about an aggregate EU pattern of 'jobless' growth, it seems more appropriate to talk about a pattern of insufficient growth, particularly in the larger

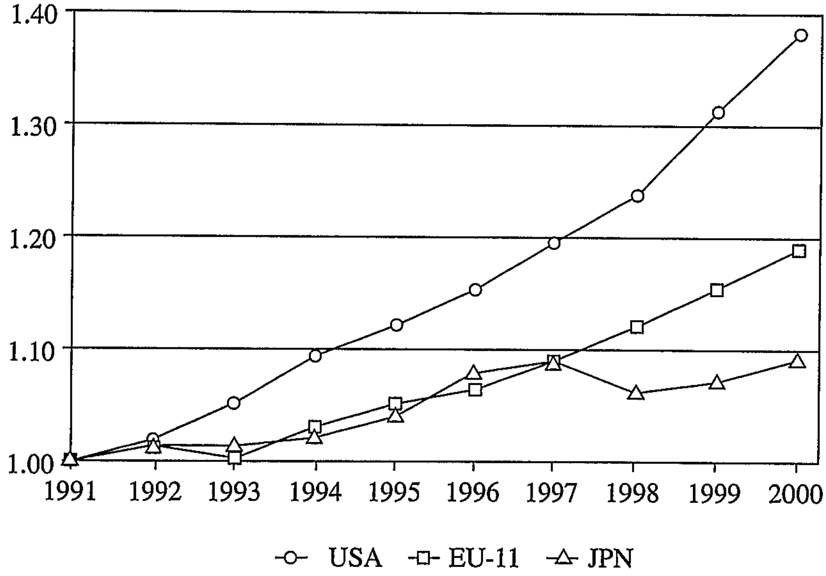

Figure 2.1 GDP 1991–2000 (1991 =1)

European countries, to generate sufficient new job opportunities for unemployment to come down and new entrants to appear on the labour market. Indeed as Figure 2.2 shows, Europe witnessed a major employment crisis in the first half of the 1990s.

Combined, these two trends indicate that the substantial gap in aggregate economic welfare (real GDP per capita) between the US, the EU and Japan, some 30–20 per cent at the beginning of the 1990s has actually widened over the last decade, as illustrated in Figure 2.3. Again the GDP per capita levels in 1991 have been set at 1 so as to observe the trend between the EU relative to the US and Japan. Real GDP per capita in the US rose over the period 1991–9 by some 18 per cent, or 2.12 per cent annually. The EU countries saw real GDP per capita grow by some 13 per cent, or 1.62 per cent per annum, while Japan did not observe any rise in its real GDP per capita. From the EU countries, Ireland, Denmark and the Netherlands faced the largest increases in real GDP per capita over the 1990s.

The trends observed in Figure 2.3 are particularly striking when put in their historical context. To illustrate this, Figure 2.4 shows the relative growth performance, i.e. growth of per capita GDP, of a sample of OECD countries relative to the US. All four periods analysed, i.e. 1913–38, 1950–73, 1973–91 and 1991–2000, show a convergence pattern between the group of followers. The horizontal axis of Figure 2.4 measures the gap in

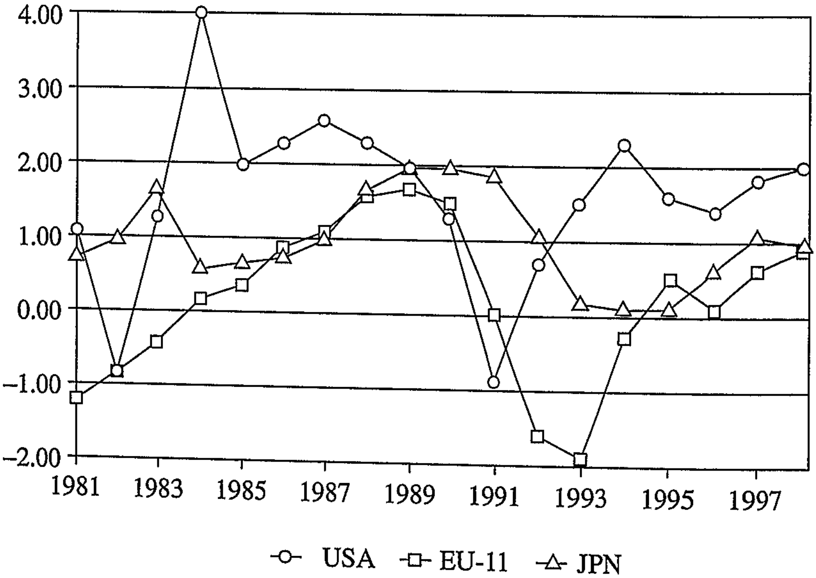

Figure 2.2 Employment 1981–1998

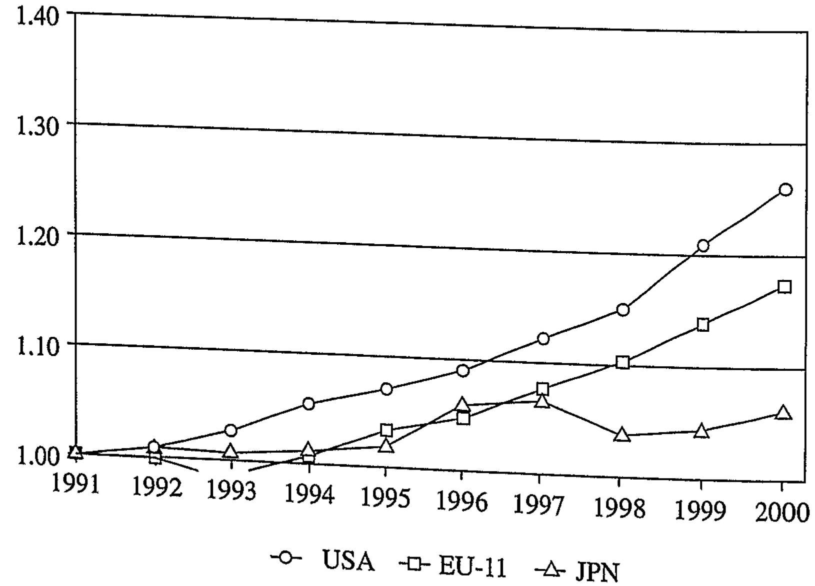

Figure 2.3 GDP per Capita 1991–2000 (1991 = 1)

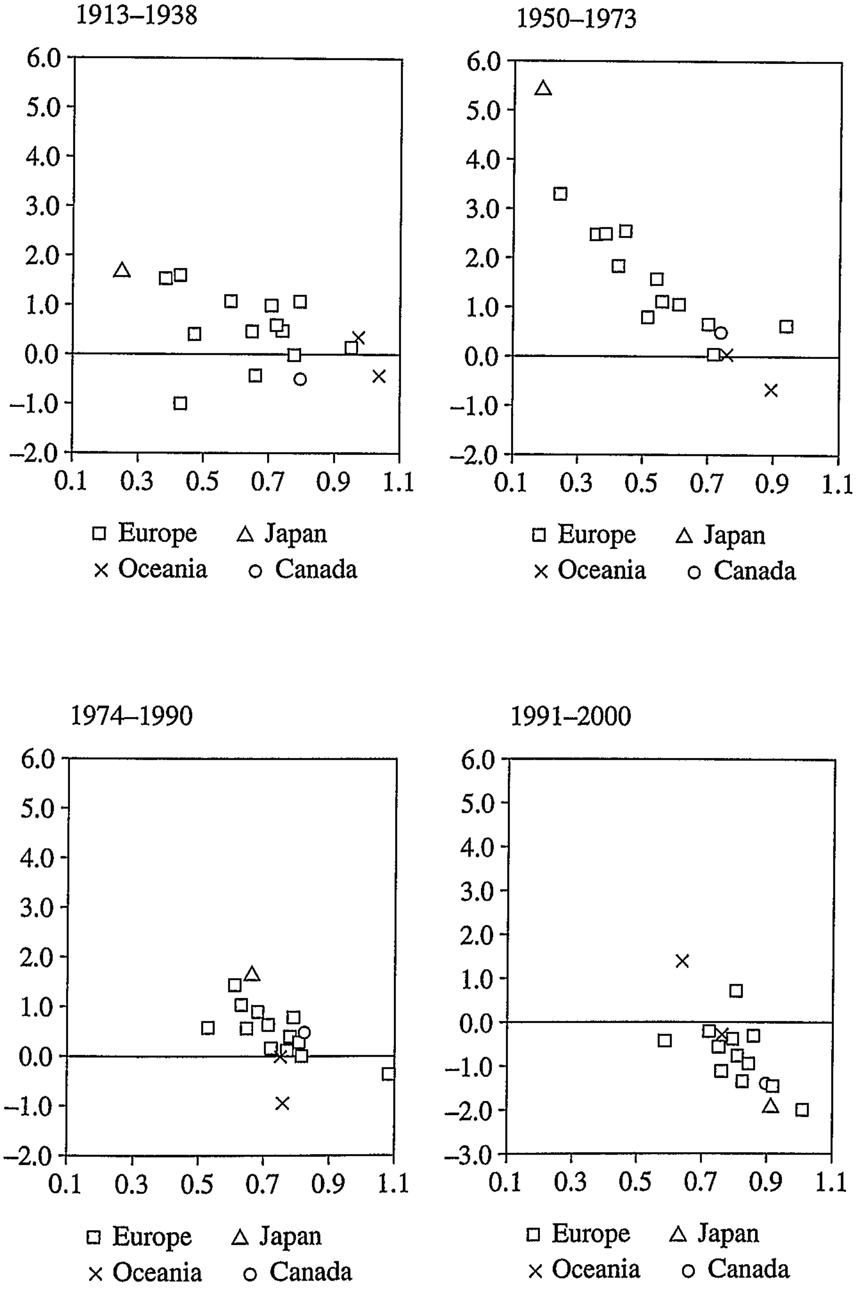

Figure 2.4 Convergence and divergence relative to the United States

the initial year. The vertical axis measures the growth rate of this gap for the relevant period. This gap is defined as

$$G_t = \frac{Y_{it}}{Y_{ust}} \tag{2.1}$$

which means that when the growth rate of G_t is positive, the gap with the US is falling, while a negative growth rate of G_t indicates that the gap with the US is rising. From Figure 2.4 it follows that in the first three periods the gap relative to the US is falling, i.e. countries are catching up with the US, while in the final period, 1991–2000, the gap with the US is increasing. For further analysis see Hollanders, Soete and ter Weel (1999).

Growth convergence *between* the various countries of the US, appears nevertheless a characteristic feature of the twentieth century. It reflects, through international trade, foreign investment, licenses and various other formal and informal information and knowledge channels, the continuous spreading of production, distribution and consumption patterns across the developed world. However, and as also shown in Figure 2.4, there has been a major shift from a general trend of catching up with the US to a new recent trend of the US suddenly increasing its lead over most other countries in the most recent period 1991–2000. As a parenthesis, it can be noted that this most recent period shows also convergence between the EU countries; at the same time the EU as a group has been falling behind the US.

From this perspective, it can be argued that the period up to 1973 was a period of rapid growth dominated by catching-up phenomena world wide: catching up of European consumption patterns to US standards; significant growth in the centrally planned economies based on further exploitation of 'Tayloristic' methods of labour organisation in agriculture and the heavy industrial sectors,[2] and the end of the de-colonisation process in most Third World countries. It was logical that through such a growth process the gap between the US and the EU and Japan would narrow down. By contrast, the US economy did, if anything, show some major weaknesses, for example in relation to employment creation.[3]

In contrast, the 1973–91 period appears to be characterised by the disappearance of such catching-up features, at least with respect to the European developed OECD world and Japan. This happened despite accelerated European economic integration with the subsequent enlargements of the European Community and the move from a customs union to an economic union. It also took place despite the gradual liberalisation of financial markets. In fact the period was characterised first by a dramatic explosion of exchange rate volatility, inflation, unemployment and public deficits. The failure of macroeconomic policies to contain inflation, reduce unemployment in Europe (with only one or two individual countries as exceptions) and control public spending is from this perspective both the consequence and cause of the halt in growth convergence and the end of what the French economic historian Forestier referred to as 'les trentes glorieuses': the thirty post-Second World War wonder years of high growth, low inflation and low unemployment.

Finally, the most recent period, from 1991 until 2000, appears as indicated in Figure 2.4d to be characterised by growth divergence between the US, Europe and Japan; effectively a leap forward by the US. This US growth divergence took place despite a major convergence between the US, Europe and Japan in aggregate economic indicators, such as inflation, long-term interest rates and public spending. It took also place despite the dramatic growth in international information and communication possibilities bringing about increased transparency.

It is hence important to re-situate in its recent historical context the continuing unexpected nature of this emerging growth divergence. First and foremost, few authors predicted the slow-down of Japanese growth. At the same time, many others predicted rapid growth in Europe because of the internal economic integration process deepening (the 1992 Single Market) and the expected rapid catching up of Eastern European countries to EU income and consumption levels. At the same time, the collapse of US growth predicted since the mid 1990s as a result of its low savings rate, high trade deficit and unsustainable growth in stock market prices failed to occur. One may thus conclude, and notwithstanding the recent growth upsurge in Europe, that for the first time in post-war history, growth divergence amongst the Triad countries has been a dominant feature of the 1990s.

Underlying the growth process over the last ten years, the question must hence be raised whether other, new factors appear to have emerged, particularly in the US. More than any other country in the world, the US economy appears to have benefited from faster application and implementation of new technologies, more rapid uptake of the new 'information highways' infrastructure and more successful world-wide commercial exploitation of these growth opportunities. In short, the US seems to have been the most successful country in making its transition to a knowledge-based economy.

2. THE EMERGING KNOWLEDGE-BASED ECONOMY

Before turning to particular trends in investment in knowledge in Europe, it seems essential to clarify somewhat the notions and concepts involved.

There is if anything today a conceptual confusion about what we have called here – using the older OECD term – the 'knowledge-based' economy, but what could be called as well the 'learning' economy (Lundvall and Johnson, 1994) or the 'new' economy. Knowledge is of course not a new concept. Its importance for economic growth was at the core of much economic thinking and writing of the late eighteenth and nineteenth centuries. One only has to think of the importance given to knowledge by classical economists, such as Marx or Schumpeter, to realise that economists, just as historians, have always been aware of the crucial importance of knowledge accumulation for long-term growth. What is new are a number of things. Without pretending to be exhaustive, we group them here under three headings: the economic integration in formal growth models of particular features of the knowledge accumulation process (as in new growth theory and beyond); the impact of new ICTs on the process of knowledge accumulation and hence also on growth ('new' economy and the emergence of open global electronic networks); and last but not least the increased importance of continuing knowledge improvements thanks to more routine use of a growing, enlarged base of codified knowledge (various interpretations of the 'learning' economy). Let us start with the first one.

Since the early 1980s, the economic profession has started to recognise the fact that knowledge accumulation can to a large extent be analysed like the accumulation of any other capital good. That one can apply economic principles to the 'production' and 'exchange' of knowledge; that it is intrinsically endogenous to the economic and social system and is not really an external, 'black box' factor, 'not to be opened except by scientists and engineers' as Chris Freeman (1972) once put it. Hence, while knowledge has some specific features of its own, it can be 'produced' and used in the production of other goods, even in the production of itself, like any other capital good. It also can be stored and will be subject to depreciation, when skills deteriorate or people no longer use particular knowledge and 'forget'. It might even become obsolete, when new knowledge supersedes and renders it worthless.[4]

But there are some fundamental differences with traditional material capital goods. First and foremost the production of knowledge will not take the form of a physical piece of equipment but generally be embedded in some specific 'blueprint' form (a patent, an artifact, a design, a software program, a manuscript, a composition) or in people and even in organisations. In each of these cases there will be so-called positive externalities; the knowledge embodied in such blueprints, people or organisations cannot be fully appropriated, it will with little cost to the knowledge creator flow away to others. Knowledge is from this perspective a 'non-rival' good. It can be shared by many people without diminishing in any way the amount available to any one of them. But of course there are costs in acquiring knowledge. A major central theme of economic theory is what is referred to as information asymmetry: the person wanting to buy something from someone who knows more about it obviously suffers from an asymmetry (a lack) of information.

It explains why markets for the exchange of knowledge are rare and why firms prefer in principle to carry out research and development (R&D) in-house rather than contracted out or licensed. It also provides a rationale for policies focusing on the importance of investment in knowledge accumulation. Such investments are likely to have high so-called 'social' rates of return, often much higher than the private rate of return. Investment in knowledge cannot be simply left to the market.

Second, the growing economic and policy consensus on the importance of knowledge for industrial competitiveness is undoubtedly also closely related to the emergence of the new ICTs. As already argued above, there is no reason to assume that the impact of new information and communication technologies would limit itself to the manufacturing and distribution of goods and services. Information technologies (ITs) are from this perspective in the real sense of the word 'information' technologies, the essence of which consists of the increased memorisation and storage, speed, manipulation and interpretation of data and information: in short what has been characterised as the 'codification' of information and knowledge. The additional Communication part in ICTs allows, however, such codified knowledge, data and information to become much more accessible than before to all sectors and agents in the economy linked to information networks or with the knowledge of how to access such networks. ICTs are hence likely to increase the rate of return to investment in knowledge, whether research, development, software or education expenditures. It is this particular feature which is identified with a possible higher 'new' growth path (see e.g., OECD, 2000; van Ark, 2000; Bartelsman and Hinloopen, 2000). Furthermore, such effects are likely to be most significant in countries where international access and transferability of codified knowledge has been difficult and costly.

It is from this perspective that the new ICTs have often been presented as the first case of truly 'global' technological transformation. The possibility of ICTs to codify information and knowledge over both distance and in real time brings about more global access. While the local capacities to use or have the competence to access such knowledge will vary widely, the access potential is there. ICTs in other words bring to the forefront the potential for catching-up, based upon cost advantages and economic transparency of (dis-)advantages, while stressing at the same time the crucial 'tacit' (that part of knowledge that cannot be codified) and other competence elements in the capacity to access international codified knowledge.

The importance of access brings to the forefront, on the one hand, the overriding importance of new communication infrastructures, not just for production and distribution but also for research and innovation, and, on the other hand, the crucial importance of the long-term availability of highly skilled manpower: not just scientists and engineers but more generally so-called 'knowledge workers': brainpower, which cannot be codified. Such human skills represent essential complementary assets to implement, maintain, adapt and use new physically embodied technologies. Human capital and technology are from this perspective two faces of the same coin, two non-separable aspects of knowledge accumulation.

Third, and as some authors in the field of innovation studies have argued, amongst them most explicitly Paul David and Dominique Foray (1995), as a result of the new ICTs the perception of the nature of the innovation process has also changed significantly over the last decade. Broadly speaking, innovation capability is today seen less in terms of the ability to discover new technological principles, than in terms of the ability to exploit systematically the effects produced by new combinations and use of aspects of the existing stock of knowledge, more widely and easily accessible than ever before. A similar set of arguments is made by Lundvall when he introduces his notion of the 'learning' economy. This model implies, as David and Foray have argued, to some extent more routine use of a technological base allowing innovation without the need for leaps in technology. It thus requires much more systematic access to the state-of-the-art. Universities, public and private research centres will introduce procedures for the dissemination of information regarding the stock of technologies available, so that individual innovators can draw upon the work of other innovators. The science and technology system is in other words shifting towards a more complex 'socially distributed' structure of knowledge production activities, involving now a much greater diversity of organisations having as their explicit goal the production of knowledge; what can be called learning entities. The old system, by contrast, was based on a simple dichotomy between deliberate learning and knowledge generation (R&D laboratories and universities) and activities of production and consumption where the motivation for acting was not to acquire new knowledge but rather to produce or use effective outputs. The collapse, or partial collapse, of this dichotomy conducts to a proliferation of new places having the explicit goal of producing knowledge and undertaking deliberate research activities. It raises obviously fundamental challenges as to the institutional adaptability of the still very fragmented and very 'dichotomised' European science and technology system. As argued in the fourth section this is precisely one of the areas where the US appears to have been more successful over the last decade.

It is important from this perspective to put the organisation of Europe's science and technology system in its own historical perspective. Science and technology has of course been the subject of national public interest and support for centuries. Large popular support for such activities was obtained by stressing the national security need and national prestige nature of such activities. At the European level, such national security or prestige arguments rarely developed, rather the contrary. Over the late 1970s and 1980s one witnessed a shift away from centralised public support for 'big science' areas considered of strategic importance, such as nuclear energy research (EURATOM) and aeronautics. The scope of such policies had been simple and in line with the early European integration aims: reap possible scale economies in production and large-scale research investment and secure European autonomy. Organisations such as CERN (European Council for Nuclear Research), ESA (European Space Agency), EMBL (European Molecular Biology Laboratory) became showpieces of European cooperation successes in science. With time passing though and the large nuclear energy and fusion programmes not developing their long-held economic promises, a new form of technology-based, industrial policies for new sunrise sectors, such as microelectronics, in the form of so-called 'pre-competitive' research support was developed. In their emphasis on competitiveness, such policies did of course overlap with national technology policies with the 'subsidiarity' principle more or less invented as belated legitimisation of existing flows of money and responsibilities between EU, national and in some member countries regional authorities. By adding some specific European networking requirements, such support policies did, however, respond to an apparent European need for more networking across different relatively closed research communities. Unfortunately, as such policies developed and started to eat up a growing and larger part of the European budget, the high-tech industries and large European firms which benefited most from such European pre-competitive research support programmes appeared to be those sectors and firms which came to lose most in terms of world market share. Hence, despite a growing European research budget, Europe has been losing ground most in international competitiveness in high-tech sectors.

Not surprisingly, the 1990s witnessed a significant shift in European policy making in the science and technology area. This shift can be best described as a shift in the nature of the public support: away from science and technology push towards more demand–pull policies, with greater acceptance of the crucial role of users and the intrinsic recognition that technical success does not necessarily imply economic success. The Commission's 'Green Book on Innovation' provided probably the most explicit recognition of the need for this shift towards innovation policies, describing Europe's failure in developing new products and new-technology based firms as a European technology paradox: excellence and strength in basic and fundamental research yet failure to translate this in commercial excellence and success.

Underlying this diagnosis and policy shift, there is, however, and in line with the argument set out above, a growing recognition that technical change in the highly developed, open societies of which Europe is composed is a complex dynamic process that involves many social and economic factors and a wide range of individuals, institutions and firms and hence is crucially dependent on effective networking between them.

From this perspective the capacity of Europe's economy to derive competitive advantage from technical change and innovation is more than ever dependent on the dynamic efficiency with which firms and institutions diffuse, adapt and apply information and knowledge. Within a context of fifteen different EU countries, each with their own, historically long-established science, technology and higher education institutions, long-term national networks of public and private research organisations and national policy makers in search of national prestige and recognition, this is a major policy challenge.

3. IS EUROPE FALLING BEHIND IN KNOWLEDGE INVESTMENT?

From our previous discussion it will appear clear that there is no simple, agreed measure or notion, which could in a satisfactory way represent 'knowledge'. From what has been said above it will be clear that different components of capital and labour need to be taken into account in assessing the knowledge intensity of an economy. In a recent OECD report (1999), an attempt is made to bring together a number of knowledge intensity measures. Below, we compare some of these measures for the US, Europe and Japan,

In Figure 2.5, we compare the investment in tangibles, i.e. physical investment, and in knowledge as a percentage of GDP for the US, the EU and Japan for 1995. Japan has the highest physical investment intensity and the lowest knowledge investment intensity. By contrast, the US has the highest knowledge investment intensity and the lowest physical investment intensity. The position of the EU is in between. Countries such as Italy, Belgium, Germany and Austria have all knowledge investment intensity levels below the EU level; countries such as Sweden, France, Denmark, Finland and the UK have above EU knowledge investment intensity levels. If private spending on education and training had been included in Figure 2.5, the US figure would undoubtedly be even higher.

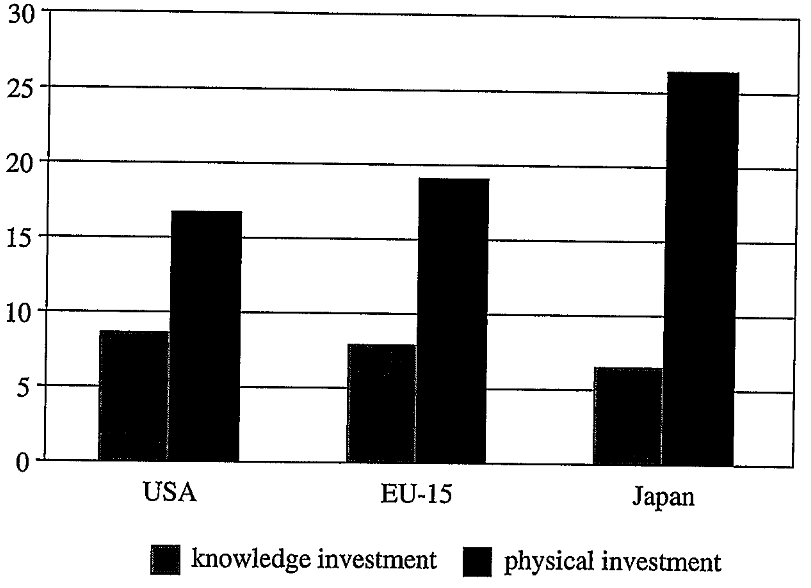

Figure 2.5 Knowledge and physical investment in 1995 (% of GDP)

Figure 2.6 represents the so-called ICT intensity – ICT expenditures as a percentage of GDP – for three different ICT components – IT hardware, IT services and software and telecommunications – for the US, Japan and the EU average for 1997. Of the individual EU member countries, only Sweden has now a higher level than the US and only Sweden and the United Kingdom have a higher level than Japan.

In Figures 2.7 and 2.8, the US efforts with respect to R&D expenditures are further compared with the expenditures for the EU in absolute, but real terms. This is done for the major two components where R&D is being carried out: so-called BERD, standing for Business Expenditures on R&D, in Figure 2.7 and GOVERD or government expenditures on R&D in Figure 2.8.

The trends in the Figures 2.8a and 2.8b are striking: an impressive gap between the US and Europe over the 1990s has emerged in privately carried out R&D. The US is today investing twice as much on business R&D as Europe; the current R&D gap is, as Figure 2.8b illustrates, more or less equivalent to the total EU R&D effort. By contrast in government carried out R&D the opposite is now true: Europe spends now nearly 25 per cent more on R&D than the US.

The data presented here without claiming to provide a complete picture are nevertheless striking in illustrating the way Europe appears to have

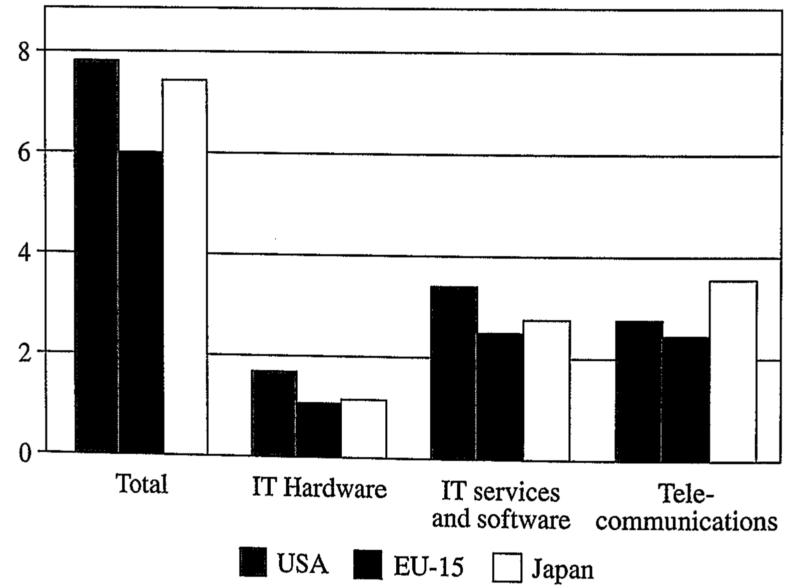

Figure 2.6 ICT expenditures in 1997 (% of GDP)

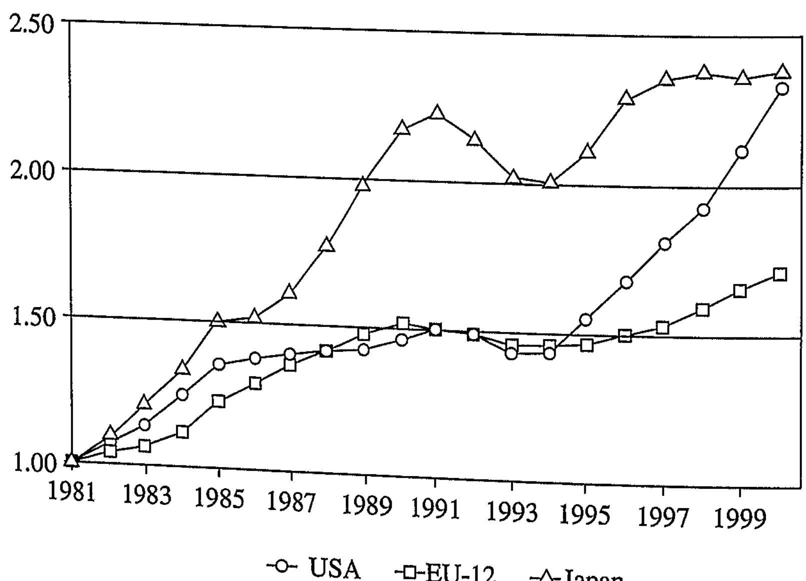

Figure 2.7a BERD 1981–2000 (1984 = 1) (Original series in 1990$PPP)

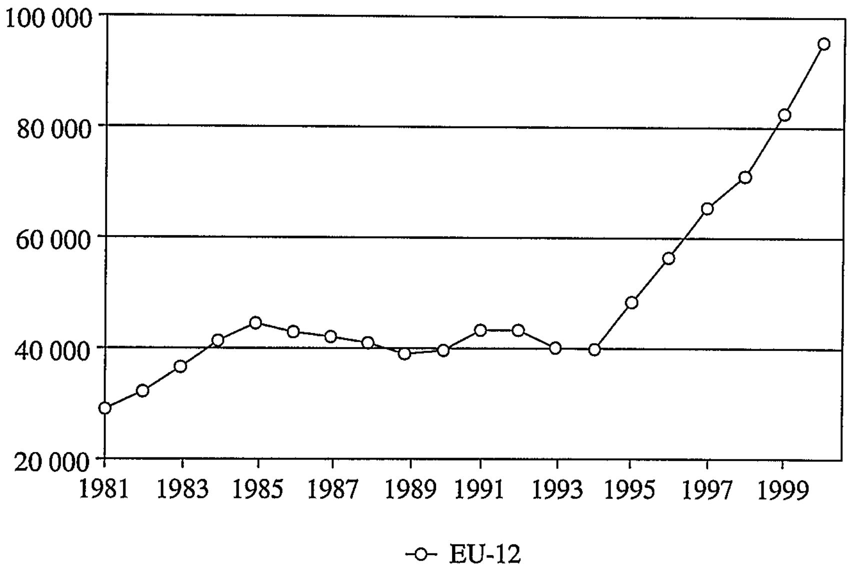

Figure 2.7b BERD US-EU-12 (1981–2000 in million 1990$PPP)

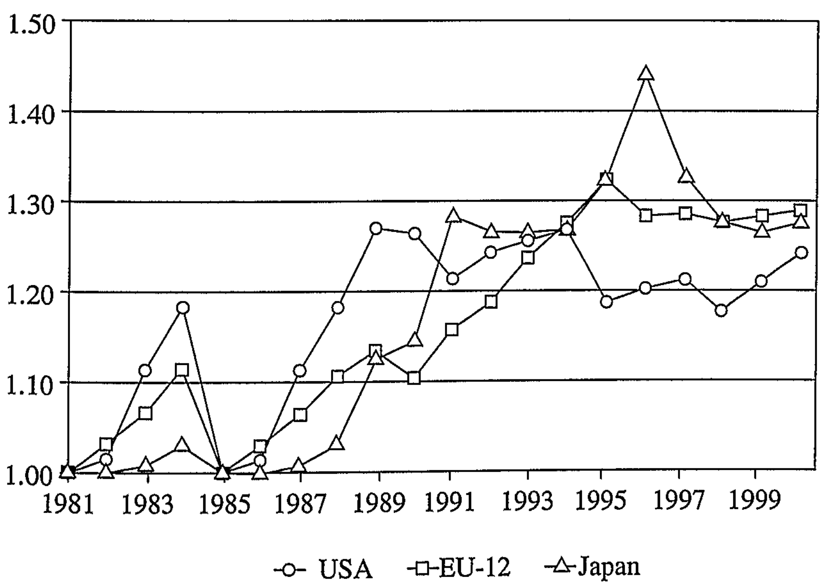

Figure 2.8a GOVERD 1981–2000 (1981 = 1) (Original series in 1990$PPP)

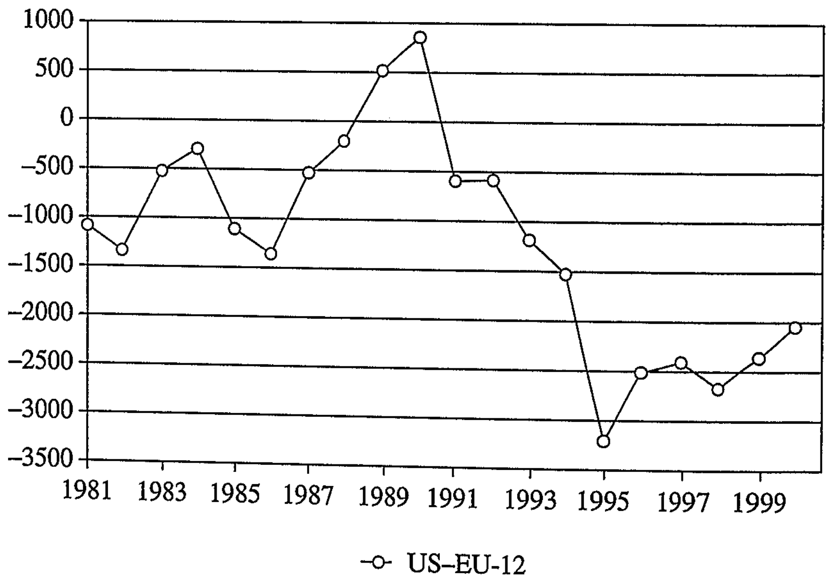

Figure 2.8b GOVERD US-EU-12 (1981–2000 in million 1990$PPP)

failed to invest in knowledge over the last decade: in R&D and ICT investment in particular. There is now a substantial gap in such investments in the business sector between Europe and the US. On the face of the data presented here, Europe seems to have missed its transition to the knowledge-based economy.

4. THE TRANSITION TOWARDS A KNOWLEDGE-BASED ECONOMY: WHAT CAN BE LEARNT FROM THE US EXPERIENCE?

In this last section we now turn in more detail to the US experience, as it appears to have shifted in a more successful way its economic base in the direction of a knowledge-based economy. In doing so we will follow the three features that are at the core of the new importance given to knowledge accumulation as presented in the second section.

We start with the 'new' financial and economic recognition given to knowledge as exemplified in new growth models. One may argue that in the US in particular the early recognition by the financial world of the intrinsic value of knowledge accumulation has been behind a much greater readiness by the financial sector to invest in new, often purely knowledge-based firms. From this perspective, the growth of an effective venture capital market whereby the resources to invest in knowledge accumulation could be extracted from the financial market appears to some extent to have been a crucial institutional innovation. Both in Japan and Europe (with the partial exception of the UK), the financial sector remained heavily 'material'-biased, often being formally involved or part even of the large industrial firms' management. Hence, the total market capitalisation of firms in the US has been much larger than in many continental European countries as compared for example, to their respective GDPs. Furthermore, the largest capitalised firms in the US are today practically all involved in knowledge accumulation activities rather than just material goods.

As Schumpeter in particular emphasised, the stock market was an essential institutional innovation accompanying the growth boom of the 1920s. It could well be argued that venture capitalists, the creation of NASDAQ and other financial innovations have allowed the mobilisation of private capital for investment in knowledge accumulation activities and have thus become an essential institutional innovation for the emerging knowledge-based economy. By the same token, at the macroeconomic level, given the importance of the stock market for additional income and earnings supplements (one may think of payments in options) for high-skilled knowledge workers, it could be argued that, consciously or not, a major macroeconomic innovation was introduced in the US by the Fed under the reign of Alan Greenspan. As a result, US monetary policy started to focus more on stock market developments than just money supply, hence signalling a shift in aim and purpose of the role of fiscal and monetary policy in a knowledge-based economy. Thus, while fiscal and budgetary policy is heavily restricted and focused on long-term policy aims (ageing of population, health costs, etc.), monetary policy has effectively been more relaxed and less related to inflationary fears, but rather enabling investments in new knowledge areas and further stock market valuation and expansion. The difference with what happened in Europe is from this latter perspective striking.

The second major feature in which the US appears to have been more capable of adjusting its economic structure to a knowledge-based economy is of course investment in ICTs. As illustrated in the previous section, investments in ICTs have been much higher in the US than in both Europe and Japan. Not surprisingly, the US appears to have been much more capable of benefiting from the emerging ICTs, contributing approximately to one-third of aggregate economic growth (US Department of Commerce, 1999), a figure, equal to the difference between US and EU economic growth over the 1990s as we saw in Section 1. There are several reasons each one insufficient in itself to explain the relative success of the US. Thus, there has been the dramatic revival of the US semiconductor industry following the US–Japanese semiconductor trade agreement, effectively providing breeding space for such revival. There has also been the successful alliance between software and semiconductor industry allowing for an effective commercial exploitation of technological improvements in the computer industry. Authors, such as John Zysman, refer in this context to the notion of 'wintelism': the combination of continuous technological improvements in chip performance (such as the Pentium from Intel) and in operating systems (such as Windows from Microsoft) requiring extensive performance capacity. Thanks to the combination of free local telecom access, expertise in hardware and software network technologies going back to DARPA and ATT (e.g., Sun and the software languages UNIX, Java and now Jini) and the development of a universal Internet Protocol (Netscape), Internet use rose rapidly outside of the traditional scientific community and was quickly taken up by businesses and individuals. Finally, the availability of extensive content (film, television, radio, press) provided a rapid take-off in terms of new Internet services.

The result has been that the US leads the world in Internet use and pricing, in number of websites, Information Service Providers, hits, sales on e-commerce, etc. The growth in employment in these ICT-related sectors has been significant, as has been the volume of international trade generated. The international US competitiveness in these sectors has undoubtedly been greatly enhanced by the imposition world wide of strong intellectual property regimes in the area of copyrights, trademarks and authorship rights.

But the final consumer end of these new ICT-based sectors is of course only one part of the 'new' growth story. Probably even more important has been the impact on firms' internal efficiency, the impact of so-called business-to-business e-commerce (OECD, 1998). The increased potential for codification and transferability allowed for by ICT enables also for significant reductions in transaction costs; for a process of des-intermediation and decentralisation of activities and more global direct distribution and access. Not surprisingly, the concept of the 'new economy' encapsulating some of these new growth features associated with ICTs has been primarily popularised in the US.

As third new knowledge feature, it could be argued that the US science and technology system has been much more successful in responding to the new, more complex knowledge production and distribution model associated with the new knowledge-based economy and described in Section 2.

First of all, as Nelson (1993) has described in great detail, the US national innovation system has traditionally been characterised by a university system, which was diverse (public–private; local–state; specialised–

broad), closely integrated with the private sector, and particularly strongly performing. Second, with the Bayh–Doyle act of 1981, the US has obtained strong first-mover advantages in valorising particular pieces of university research: one might say the 'commodification' of pieces of knowledge. Such a 'commodification' process has undoubtedly restricted the public use of university research results. Yet it has provided a major incentive to private firms to rely on university research for some of their own, too complex fundamental research activities and created a legally clear environment for university spin-offs, providing a major incentive for university staff to set up new private ventures. These trends are clearly reflected in the figures presented in Section 3 about Europe's private business knowledge investment gap. Europe has been lagging behind in allowing universities to take out patents (in most European countries, the individual university professors take out the patent) and shifting patent law to allow for university research to be patented. In fact, this has meant that in areas such as biotechnology and medical technology the leading position of some European countries has become eroded over the 1980s and 1990s.

As the figures in Section 3 illustrated, while awareness of both European and Japanese structural weaknesses in their innovation systems, and in particular their university systems, increased over this period, policy action continued to suffer from fragmentation and the dominance of the old national institutional bottlenecks. Thus, and particularly with respect to European Commission policy initiatives, the focus has continued to be primarily on fostering intra-European cooperation in the field of pre-competitive R&D, university researchers, and various support programmes for particular technology fields: the so-called framework programmes and other related technological support programmes. Unfortunately, compared to national resources the EU resources available were too limited to make any impact on shifting or redirecting countries' own national priorities in supporting investment in knowledge accumulation. At the same time, the policies seemed overly dominated by the overriding aim of intra-European research collaboration. While the latter is still welcome in specific cases, the essential research collaboration in the new complex knowledge production model is more likely to be of a global nature, going well beyond the European borders, and unlikely to allow itself to be described in terms of pre-competitive. Hence, there might even have been a case of knowledge acquisition 'diversion', the intra-European knowledge exchange and networking having taken place at the expense of extra-European exchange and networking.

Elsewhere (Soete, 1996), I called this a 'European paradox'. As Europe invested in intra-European research, in the collaboration and exchange of scientific knowledge among European scientists and in the technological strengthening of the competitive potential of European firms, the advantages of such geographically 'bounded' collaboration became marginal, given the dramatically increased opportunities for the fast international exchange of information and cooperation.

Obviously the analysis presented here in these few pages remains incomplete. Much more could be said about European performance in the three areas identified here. In some of these, such as Europe's higher education and university system, the picture drawn here, particularly in comparison with the US, is not so bleak. As the recent report of the US Council on Competitiveness (Porter and Stern, 1999) indicates, the US is also confronted with major policy challenges particularly in the field of federal support for long-term, basic R&D, weak secondary school performance and the declining pool of scientists and engineers engaged in R&D. The policy challenges raised by the transition to a knowledge-based economy are global and certainly not limited to Europe. Below we draw some policy conclusions for the European Union, which follow from our analysis.

5. POLICY CONCLUSIONS

Three sets of policy conclusions emerge in a relatively straightforward manner from the analysis presented above. They can be organised along the three main 'new' features associated with the knowledge-based economy discussed in Section 2 and analysed in more detail with respect to the US in Section 4.

1. The transition towards a knowledge-based economy requires a major investment effort in what can be defined today as knowledge investment: R&D, software, ICT hardware, telecommunications, education and training. While the amount of public support in Europe for some of these knowledge components – in particular education and government sponsored R&D – has been more or less in line with the US, the expenditures carried out in the business sector of the economy have been lagging behind dramatically over the 1990s. This holds for R&D, software, ICT investments and private spending on education and training. It is as if in Europe, both the business and financial community have not as yet discovered the economic value of knowledge investment. There are undoubtedly many reasons for this. Some might be culturally determined, others have to do with the performance of European financial markets. It appears likely that European financial markets are still suffering from their fragmentation. It is obvious that the European Union, particularly in areas such as venture capital, has

not yet realised the scale advantages of its large financial market. Yet the readiness to take risks, to provide capital to small and medium-sized economies (SMEs), to identify new investment opportunities in new areas are all closely related to the size of the market. All this calls for new priority setting in both the business and financial communities of Europe in knowledge investment. The fact that it is in particular private investment in knowledge activities which appears to lag behind what is happening in the US raises the question whether there is not a more systematic need for a new, common European fiscal regime for such expenditures. The US Council on Competitiveness makes a plea for making the R&D tax credit permanent so as to encourage higher R&D investment in the private sector. In many EU countries such tax credits do exist. However, they are often of a very different nature: in some countries limited to small firms, in other countries to particular regions. A common EU tax treatment of R&D would improve transparency and have an overall positive effect on R&D investment across Europe.

2. Europe's lagging *vis-à-vis* the US in the area of ICT investment and ICT use hides a much more diverse internal EU picture. Thus some member countries, such as Finland or Sweden, are world leaders in number of Internet hosts; others, such as Norway or Denmark, in number of household PC penetration; yet still others, such as Ireland, in ICT-related services growth, or in The Netherlands growth of mobile phones. Much can be learnt from these different European experiences, certainly when they are enlarged to include also the use of ICT in public and private services. There is a great potential here for cross-European learning. This includes systematic intra-European comparisons in the use of ICT in education (primary, secondary and higher), in health, in public administration, and in the many other public and semipublic areas of the economy, where competitive pressures are unlikely to bring about more rapid diffusion of ICT. There are clearly two sides to Europe's overall lagging behind the US in ICT. The first, more supply side set of arguments is linked to Europe's more general weakness in entrepreneurship and innovation. This has probably been even more the case in some of the most dynamic ICT areas: creating software tools, developing content industries. Europe's failure in these areas is hence not just the result of a lack of risk capital, of a cheap and transparent, common intellectual property regime, or of the dominance of national telecommunications monopolies, but of a broader systemic failure to develop new, fast-growing ICT and knowledge-based firms. The second, more demand side set of arguments emphasises the low adoption rate of ICT equipment and use. European

firms appear to have been much slower than their American and Japanese counterparts in learning how best to adapt their organisations to the new technologies. Yet again this aggregate picture hides a very diverse pattern. Comparing across Europe various forms and experiences of organisational learning is hence another area where significant insights can be obtained.

3. Both the European innovation and its science and technology system appear insufficiently adapted to the new challenges of the knowledge-based economy. There is here an urgent need for institutional adaptation. The EU can be instrumental in bringing about such institutional renewal, highlighting the overlapping and fragmentation of current national systems and inducing cross-European mobility. European networking in science and technology should aim at reaping both scale and scope advantages from existing European research activities. At the limit this does not require additional public research funds, but rather more efficient use, organisation and implementation of existing resources. The argument of a European research paradox hides to some extent the way, basic and fundamental research is still poorly organised in Europe, with national (sometimes regional) and European support programmes overlapping and widely different quality assessment of research performance. With European governments spending some 60 billion euro and the EU some 4 billion euro on R&D, national policy priorities continue to dominate the European research agenda and national institutions the implementation. There is, hence, a clear need for a new policy approach based on 'true' subsidiarity and networking aimed at reaping scale economies so as to improve European research quality. Compared to the US National Science Foundation (NSF) or National Institute of Health (NIH), Europe lacks so far the institutional framework to develop and implement its own research agenda. By contrast, at the innovation and technology level, apart from a number of specific regulatory areas, in which the setting of for example common technical standards and norms at the European level is likely to help firms in reaping scale economies, European technology policy should aim more at reaping some of the existing scope advantages of the large diversity and variety of current European research, as we already discussed above with respect to ICT use. Networking and subsidiarity are again essential to exploit such scope advantages, but rather of the opposite nature of the one described above. Thus the subsidiarity argument will rather put the emphasis on the contribution of local, regional authorities, and networking will aim at valorising cultural, historical and institutional differences so as to improve comparative learning and implementation. At the regional level, European

science and technology policies should try to foster the openness of local actors – universities, high schools, publicly funded research organisations, local SMEs, particularly in the high-tech sectors, and local subsidiaries of 'foreign' firms – whereas regional authorities' science and technology policies should aim at internalising the growth spill-overs of regional research. Both policy aims are clearly complementary.

We did not address here some of the other issues which emerged from our analysis and in particular the crucial importance of human capital investment for knowledge accumulation. This issue is more explicitly discussed in Robert Lindley's contribution to this book (1999).

POST SCRIPTUM ON THE LISBON EUROPEAN COUNCIL AND PORTUGUESE PRESIDENCY FROM THE PERSPECTIVE OF KNOWLEDGE INVESTMENT

The widely held view that the Lisbon summit was a success was largely based on the substantial agreements achieved on the two major Commission initiatives in the area of knowledge investment incentives as reported here: the proposals surrounding the so-called 'e-Europe' initiative putting forward with a clear time framework a number of specific ICT and Internet-use targets each member country should try to achieve; and second the concept of a European common research space proposing a policy line of action to overcome the many costs of 'non-Europe' in the area of research, development, innovation and entrepreneurship. Time will tell whether the broad policy agreement amongst the heads of states achieved at Lisbon on 23 and 24 March 2000 will be translated into effective policy action and ultimately lead to Europe becoming 'the most competitive and dynamic economy in the world'.

What is, with hindsight, particularly noticeable is that the Lisbon European Council took place at the height of the stock market's evaluation of Internet dot.com shares (the so-called technology, media and telecoms sector) and the US dominance of the 'new economy'. The poor growth and knowledge investment comparison of the EU with the US, also highlighted here, was hence not just extremely timely, it was also magnified. Since then, the dramatic decline in dot.com shares over the remainder of 2000, the growth slowdown in the US, the non-election of Al Gore – the Internet vice-president – have all contributed to a more sceptical view around the sustainability of the US new economy growth model. They have not, however, rendered the diagnosis of Europe's failure in knowledge investment any less instructive. Indeed, the slowdown of US growth and the likely slowdown of European investments in the US and of take-overs of US companies has so far not been accompanied by a major upsurge of such investments in Europe.

Nevertheless, what the recent US growth slowdown has brought to the forefront is that intra-European 'best practice' comparisons have become much more instructive particularly in the area of technology, innovation and information society policies, a line also defended here, and further endorsed in the 'Europe 2002 An Information Society for All Action Plan' prepared for the Feira European Council meeting (19 and 20 June 2000). The essential features of such benchmarking exercises are discussed at greater length in the contribution of Lundvall and Tomlinson. Suffice to emphasise here that benchmarking in this area underscores the particular strong growth and technology performance of some small 'new economies' in Europe and hence highlights also the possible, diverse routes towards the knowledge-based economy which Europe might take. For sure, and illustrated in the success stories of individual Nordic countries, there appears a Scandinavian knowledge-based economy or information society model based on trust between the citizen and the government and the efficacy of public services in embracing the new information and communication technologies. But there are other models, as the very different success stories of Ireland, the Netherlands and Portugal illustrate. Maybe it is in this simple fact: learning from Europe's diversity that one will find the secret of Europe's future success in the emerging knowledge-based economy.

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NOTES

1. The first draft of this paper was written in May–August 1999 in preparation of the Lisbon summit (23 and 24 March 2000), a number of European policy initiatives have been taken since. That is why we add a short policy Post Scriptum on the outcome of the Portuguese Presidency.
2. The impulse to growth under communism would become based on the electricity revolution and the scientific Tayloristic division of labour organisation.
3. See e.g., the various contributions to the so-called Automation debate (US Senate Committee, 1966).

4. There are today an innumerable number of studies which have articulated in quite some detail the economic principles of knowledge and knowledge accumulation. For overviews see amongst others Lundvall and Borras (1997) and the contributions edited by Archibugi and Lundvall (2001).

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